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Perforated Ray Cells in Korean Hardwoods of Berberidaceae and Euphorbiaceae[1]

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韓國産 매자나무科 및 대극科 闊葉樹材의 穿孔을 지니는 放射組織 細胞[1]

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ABSTRACT

In present study, perforated ray cells were recorded for the first time in the species of *Berberis amurensis* and *Berberis poiretii* (Berberidaceae) and *Mallotus japonicus* and *Sapium japonicum* (Euphorbiaceae) that grow in Korea. These ray cells had simple perforations in the above species which had vessel elements with simple perforations. In Korean Berberidaceae and Euphorbiaceae, thus, the perforation types of perforated ray cells appeared to be identical with the types of perforation plates in the vessel elements in the same wood.

Key words : *perforated ray cells*, Berberis, Mallotus, Sapium, *Berberidaceae*, *Euphorbiaceae*.

要 約

本 硏究는 매자나무科의 매발톱나무와 당매자나무 그리고 대극科의 예덕나무와 사람주나무에 있어서 木部 放射組織내에 穿孔을 지니는 放射組織 構成細胞가 存在함을 처음으로 報告하는 것으로써 穿孔을 지니는 이들 放射組織 細胞의 穿孔은 導管要素에 發達하는 穿孔과 同一하게 單一穿孔을 지니는 것으로 밝혀졌다.

INTRODUCTION

Perforated ray cells are secondary xylem ray cells, derived from ray initials, and are of the same dimensions or larger than the adjacent ray cells, but have perforation plates and lateral wall pitting like vessel elements (Carlquist, 1988 ; IAWA Committee, 1989). These ray cells connect a vessel on one side of a ray with a vessel on the opposite side of that ray through perforation (Bottoso and Gomes, 1982 ; Otegui, 1994), and the ray cells with perforations were referred to as perforated ray cells (Chalk and Chattaway, 1933) or as vascular ray cells (McLean and Richardson, 1973). They may occur either individually or in radial or tangential rows, and radial rows of perforated ray cells with perforations in tangential walls have been described as radial vessels (van Vliet, 1976 ; IAWA Committee, 1989). The type of perforation in a perforated ray cell may be simple, scalariform, reticulate, or foraminate, and does not necessarily coincide with the type of perforation plate occurring in the vessel elements of the same woods (Rao *et al.*, 1984 ; IAWA Committee, 1989).

Since Chalk and Chattaway (1933) recorded for

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the first time the occurrence of perforated ray cells in a number of families, this cell type has been commonly reported in hardwoods : Carlquist (1960, 1982, 1983, 1989), Stern (1967), Koek-Noorman (1970, 1972), McLean and Richardson (1973), Koek-Noorman and Hogeweg (1974), Miller (1975), Nazma *et al.* (1981), Bottoso and Gomes (1982), Carlquist *et al.* (1983), Teixeira (1983), Dayal *et al.* (1984), Rao *et al.* (1984), Rudall (1985), Baas *et al.* (1988), Zhang and Baas (1992), Norverto (1993), Eom (1994), Eom and Chung (1993, 1995, 1996, 1997, 1998), Otegui (1994), Nagai *et al.* (1994), Machado *et al.* (1997), Jansen *et al.* (1997), Noshiro and Baas (1998), and Lindorf (1999).

Until recently, perforated ray cells have been recorded in 15 families, 26 genera, 35 species in Korean hardwoods by the authors and their perforation types were generally identical to the types of perforation plates in the vessel elements of the same wood.

To our knowledge, there have been no previous records of perforated ray cells in Korean Berberidaceae and Euphorbiaceae, and thus this paper reports the occurrence and type of perforated ray cells in their secondary xylems.

MATERIALS AND METHODS

The wood species investigated are listed in Table 1. The scientific names of species were based on Kim (1994).

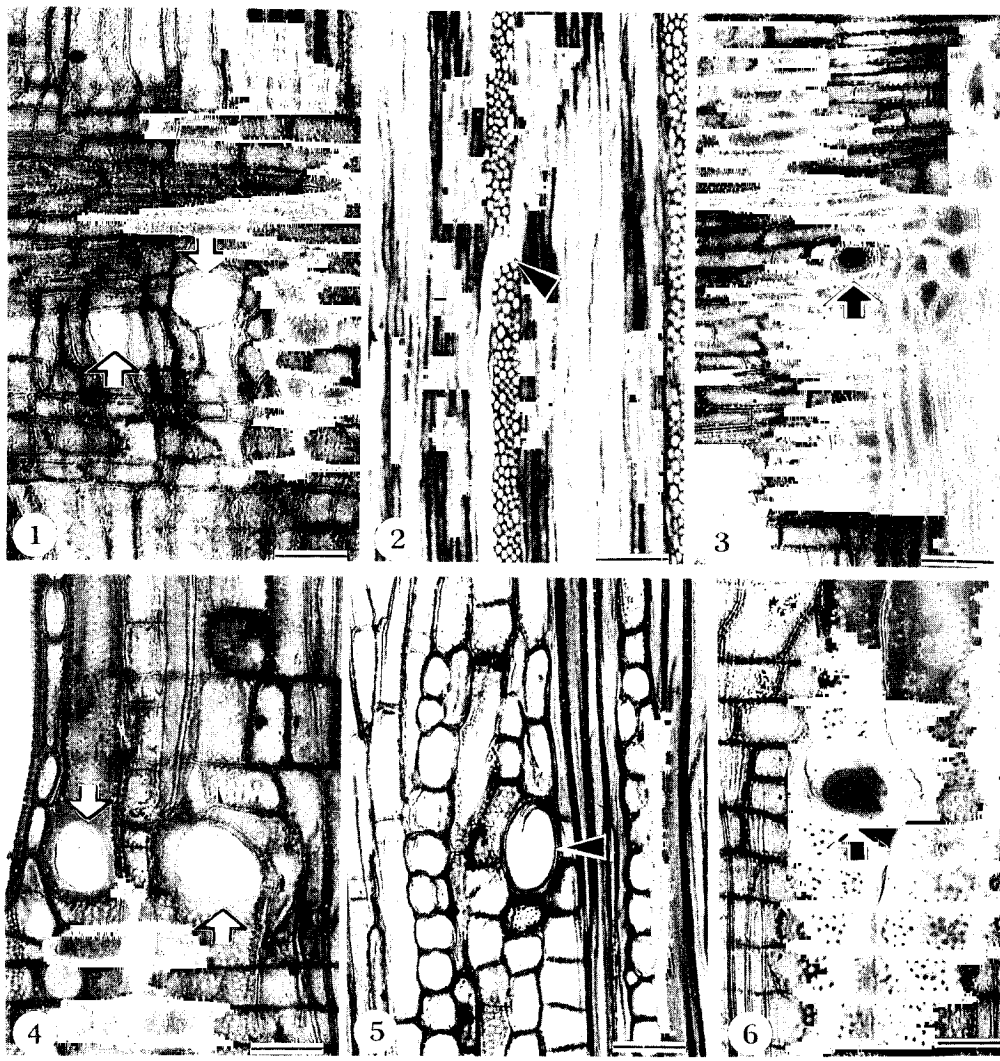
Wood samples were obtained from the collections in Wood Anatomy and Physics Laboratory, Department of Forest Products, Kookmin University, Seoul and in Mt. Chiri located in the southern part of the Korean Peninsula. Small wood blocks of about 1 cm^3 size were cut and softened in water in an autoclave, followed by immediate storage in a mixture of equal volumes of glycerine, ethyl alcohol, and water till sectioning (Berlyn and Miksche 1976). Transverse, radial, and tangential sections of 20 to 30 μm thickness were cut with a sliding microtome and permanent slides were prepared after staining with safranin, dehydration in ethyl alcohol and xylene series, and mounting with Canada balsam (Eom and Chung 1996). The observation and photomicrography of perforated ray cells were made in the radial and tangential sections by the aid of Axioskop routine microscope with attachment camera, Carl Zeiss, Germany.

RESULTS AND DISCUSSION

The ray cells with perforation were identified for the first time in Korean Berberidaceae and Euphorbiaceae (Table 1). The perforation plates in the perforated ray cells were all simple in *Berberis amurensis* and *Berberis poiretii* under Berberidaceae and *Mallotus japonicus* and *Sapium japonicum* under Euphorbiaceae (Figs. 1~6) and were identical with the types of perforation plates in the vessel elements of same woods. This

Table 1. Types of perforations in vessel elements and perforated ray cells in the xylem of Korean Berberidaceae and Euphorbiaceae.

Species	Vessel element	Perforated ray cell
Berberidaceae		
Berberis amurensis Ruprecht	simple	simple
Berberis amurensis var. *latifolia* Nakai	simple	none
Berberis koreana Palibin	simple	none
Berberis poiretii Schneider	simple	simple
Nandina domestica Thunberg	simple	none
Euphorbiaceae		
Aleurites fordii Hemsley	simple	none
Mallotus japonicus Muell.-Arg.	simple	simple
Sapium japonicum Pax. et Hoffmann	simple	simple
Sapium sebiferum (L.) Roxb.	simple	none
Securinega suffruticosa Rehder	simple	none



Figs. 1~3. Perforated ray cells with simple perforation in radial (arrow) and tangential (arrowhead) surfaces in Berberidaceae. 1 and 2 : *Berberis amurensis* Rupr. 3 : *Berberis poiretii* Schneid. Scale bars=50 ㎛.

Figs. 4~6. Perforated ray cells with simple perforation in radial (arrow) and tangential (arrowhead) surfaces in Euphorbiaceae. 4 and 5 : *Mallotus japonicus* Muell.-Arg. 6 : *Sapium japonicum* Pax *et* Hoffm. Scale bars=50 ㎛.

agrees with Nazma *et al.* (1981), Dayal *et al.* (1984), Rudall (1985), Eom (1994), Eom and Chung (1993, 1995, 1998), Noshiro and Baas (1998), and Lindorf (1999). Nonetheless, the perforation type in a perforated ray cell does not necessarily coincide with the type of perforation occurring in the vessel element of the same wood was noted by Teixeira (1983), Rao *et al.* (1984), IAWA Committee (1989), Otegui (1994), and Eom and Chung (1996, 1997). Recently, Nagai *et al.* (1994) reported that the perforation plates were mostly dimorphic with the total area of the openings in the perforated ray cells smaller than the perforation plates in vessel element ends. Machado *et al.* (1997) reported in *Styrax camporum* that perforated ray cells had simple perforation in root wood but scalariform in stem wood and more numerous in the root wood than

in stem wood.

Perforated ray cells in Korean Berberidaceae and Euphorbiaceae had perforation plates in their radial walls (Figs. 1, 3, 4, and 6) and in tangential walls (Figs. 2 and 5), and appeared to connect a vessel on one side of a ray with a vessel on the opposite side of that ray (Fig. 2) like the reports by Botosso and Gomes (1982) and IAWA Committee (1989). The ray cells with perforations in the radial or tangential walls were considered to connect two longitudinal vessel elements in tangential or radial direction (Teixeira, 1983 ; Eom and Chung, 1993, 1996).

In Korean Berberidaceae and Euphorbiaceae, perforated ray cells were observed in the multiseriate part of rays and ray splitting was correlated with the development of perforated ray cells in *Berberis amurensis* of Berberidaceae (Fig. 2) and in uniseriate ray in *Mallotus japonicus* of Euphorbiaceae (Fig. 5). Prior studies indicated that perforations in perforated ray cells were mostly confined to the uniseriate extensions of long rays and exclusively uniseriate rays (Carlquist, 1960 ; Stern, 1967 ; Koek-Noorman, 1970, 1972 ; Koek-Noorman and Hogeweg, 1974 ; Nazma *et al.*, 1981 ; Norverto, 1993 ; Nagai *et al.*, 1994), but they also occurred only in the multiseriate part of rays in a few genera (Chalk and Chattaway 1933 ; Botosso and Gomes, 1982 ; Dayal *et al.*, 1984 ; Rao *et al.*, 1984 ; Eom, 1994). The perforated ray cells were considered to be found sometimes in woods in which breakup of large rays into smaller segments is occurring actively (Carlquist, 1988 ; Otegui, 1994 ; Eom and Chung, 1995). Thus, perforated ray cells may not be confined only to the uniseriate extensions of multiseriate rays and uniseriate rays (Eom and Chung, 1996 ; Lindorf, 1999).

The ray cells with perforation in Korean Berberidaceae and Euphorbiaceae were usually larger than the adjacent ray cells (Figs. 1~6), although in other species they usually have the same dimensions or larger than the adjacent cells (IAWA Committee, 1989 ; Eom 1994 ; Nagai *et al.*, 1994 ; Eom and Chung, 1993, 1995, 1996, 1997, 1998).

The diagnostic value of perforated ray cells has been discussed by several researchers. Some researchers (Dayal *et al.*, 1984 ; Rudall, 1985 ; IAWA Committee, 1989 ; Eom and Chung, 1996, 1997, 1998 ; Lindorf, 1999) suggested that the presence or absence of perforated ray cells might not be useful in wood identification due to their sporadic occurrence. However, Otegui (1994) showed that perforated ray cells in *Rapanea laetevirens* and *Rapanea lorentziana* of Myrsinaceae had diagnostic value because of their regular occurrence. Absence of perforated ray cells may be due to chance because of their irregular occurrence. To our knowledge, there have been no previous records of perforated ray cells in Korean Berberidaceae and Euphorbiaceae, so the occurrence of this feature may be variable and of minor diagnostic significance in these families.

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